MAGNETOSTRICTION OF FERRITE

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The measurements of Joule (1847) first established the fact that iron, when magnetized, increased in length in the direction of magnetization and contracted at right angles thereto. The maximum changes of length which accompany technical saturation of ferromagnetics are merely 5×10^{-5} times the original length. Consequently such changes can only be measured if adequately magnified by mechanical or optical devices. In India, Bose (1907) was the first to demonstrate Joule magnetostriction with the help of a tambour chamber and a capillary manometer.

This expansion (or contraction) of the lattice is the result of interaction between the magnetic or quasimagnetic forces and the opposing purely elastic forces between the atoms. The equilibrium distortion or magnetostriction occurs when the sum of the two corresponding energies is a minimum. Van Vleck (1937) showed that spin-orbit coupling that accounts for the crystal anisotropy, gives rise to quasi-magnetic interactions of the right order of magnitude. Calculations of Vonosovsky (1940) also indicate that spin-orbit coupling can account for the observed magnetostriction. Kittel (1949) has given the analytical expressions for the magnetostriction as a function of change of anisotropy with strain. If the anisotropy is independent of the state of strain, there will be no linear magnetostriction.

The magnetic properties of ferrites have been subject to investigation of many years. Snoek (1947) has made a systematic investigation of ferrites using various bivalent metals and having diverse compositions. He found that the saturation magnetostriction of $FeFe_2O_4(Fe_3O_4)$ is positive, while that of all other single ferrites is negative, However, no relative data on the variation of magnetostriction of ferrites with composition is available. In the present experiment, a ferrite rod has been used, having the following composition :

Fe	...	49%
Ni	...	10.22%
Mn	...	0.88%
SiO_2	...	0.22%
C	...	Trace

When the components are added as metallic oxides, the total becomes roughly 100%. Presumably it is a solid solution of various ferrites having the composition $MnNiFe_4O_8$.

The ferrite rod was kept well inside a magnetic solenoid in a uniform field, minimising the demagnetisation factor. The temperature of the specimen was maintained constant by winding the magnetising coil on a water-cooled former. The specimen was mounted vertically the lower end being rigidly fixed. The upper end was attached by a quartz hook to the short arm of a long magnetic lever. In front of the opposite end of the magnetic lever was suspended a pair of astatic needles mounted on the back-surface of a thin mirror. The arrangement is, more or less, a replica of Bose's (1927) celebrated magnetic crescograph. The instrument was carefully calibrated against known longitudinal displacements and exhibited strictly linear relationship. The mathematical formulation of of its working principle also substantiated the above finding.

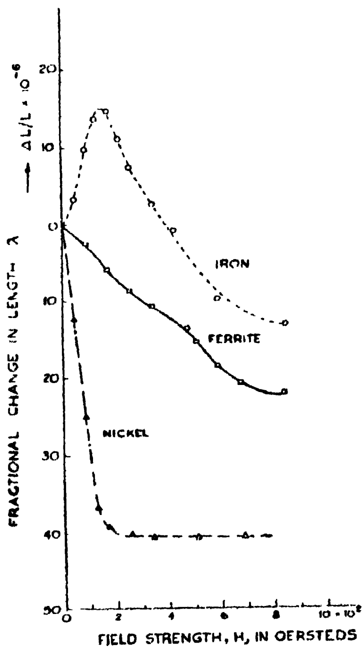

Figure 1.

In Figure 1, magnetostriction is plotted against the magnetic field strength for three materials of different kinds. The fractional change in length $\Delta L/L$, represented by the symbol λ, is measured in the same direction as that in which H is applied. It may be seen that in weak fields iron expands, while nickel and ferrite contract. In higher fields iron begins to contract, and at about $H = 500$, it becomes shorter than it was before magnetization. When the magnetization approaches saturation, the magneto-striction also approaches its limiting value, λ, the saturation magneto-striction. It is evident that the saturation magneto-striction value of ferrite is intermediate between the values of nickel and iron.

It may be mentioned here that the magneto-striction effects in three ferromagnetic materials were obtained rather easily with the help of Bose's magnetic crescograph maintained in the region of comparatively lower sensitivity. The existence of a Joule effect in non-ferromagnetic substances was first proved by Kapitaza (1932), using his magnetic balance with intense magnetic fields. It is being contemplated to measure the Joule effect in some non-ferromagnetics utililising a higher magnetic field and a magnetic crescograph operated in the region of optimum senitivity.

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